2011 AEROSE-VII
Ocean Cal/Val Campaign Summary

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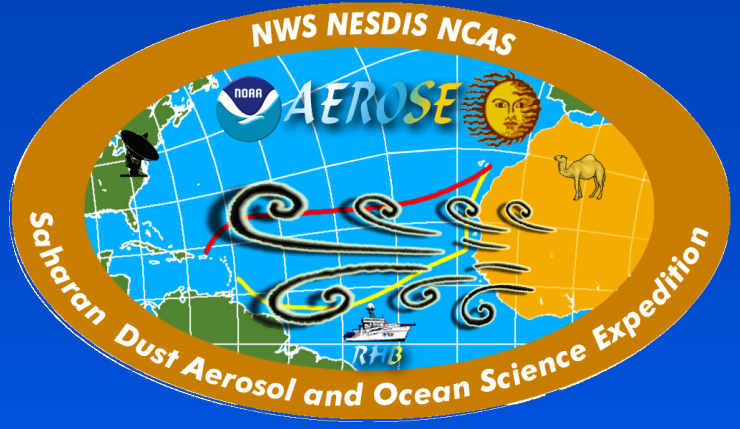
and

C. D. Barnet, E. Joseph, D. Wolfe, V. Morris, E. Maddy, M. Divakarla, T. Reale, T. King, A. Gambacorta, H. Xie, G. Guo, B. Sun, F. Tilley, R. Lumpkin, P. J. Minnett, *et al.*



NASA Sounder Science Team Meeting
Greenbelt, Maryland, USA
10 November 2011

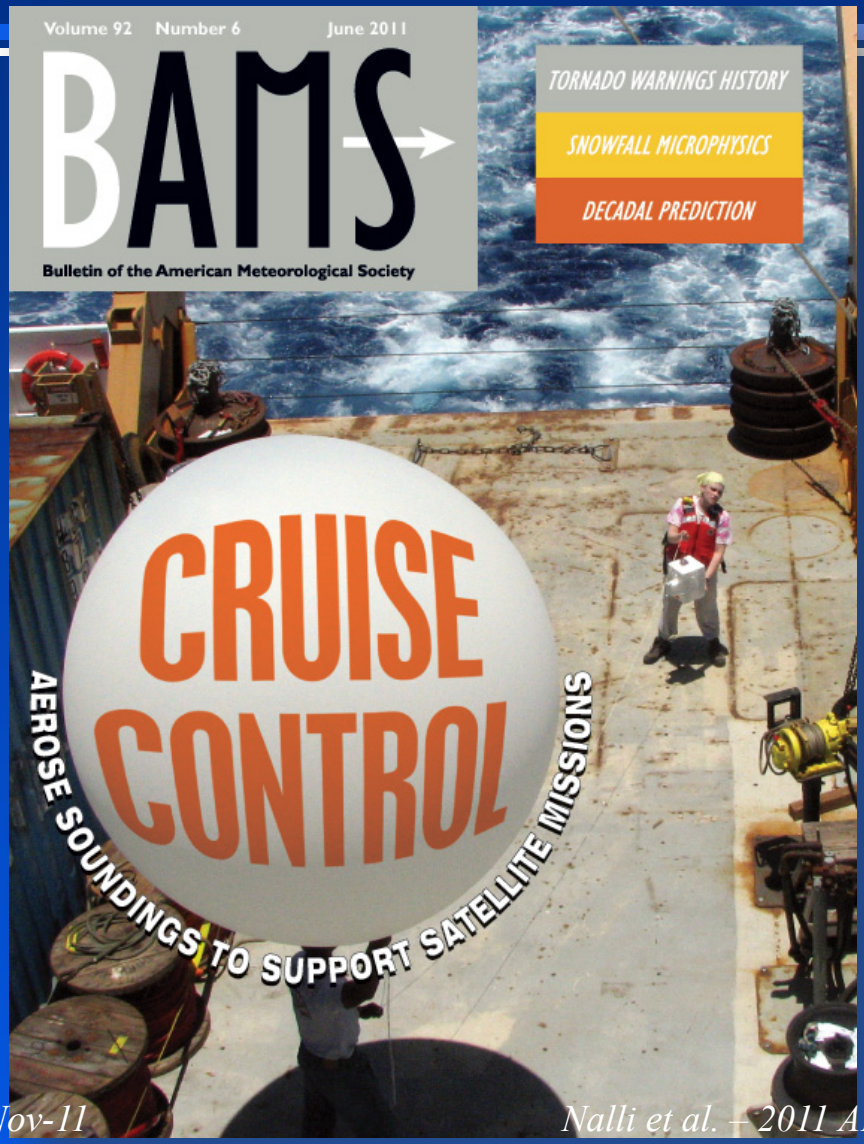
AEROSE Overview

- The NOAA **Aerosols and Ocean Science Expeditions (AEROSE)** are a series of trans-Atlantic intensive atmospheric field campaigns conducted onboard the NOAA Ship *Ronald H. Brown (RHB)*
  - AEROSE-I (March 2004; 4 weeks)
  - PNE*/AMMA*/AEROSE-II (Jun-Jul 06)
    - Leg 1 (4 weeks)
    - Leg 2 (4 weeks)
  - PNE/AEROSE-III (May 07; 4 weeks)
  - AEROSE-IV transit (Apr-May 08; 3 weeks)
  - PNE/AEROSE-V (July-Aug 09; 4 wks)
  - PNE/AEROSE-VI (Apr-May 10; 4 wks)
  - **PNE/AEROSE-VII** (Jul-Aug 11; 5 wks)

*AMMA – African Monsoon Multidisciplinary Analysis Extension

*PNE – PIRATA Northeast

AEROSE in *BAMS*!



- A comprehensive **overview paper** describing AEROSE was published as a Science Article in the **June 2011 issue** of the *Bulletin of the American Meteorological Society*
- Science topics of interest are highlighted, with emphasis given to satellite cal/val (JPSS, IASI and GOES-R)

PNE/AEROSE Partnership

- **Participating Institutions**
  - Howard University NOAA Center for Atmospheric Sciences (HU/ NCAS)
  - NOAA/NESDIS/STAR
  - University of Miami/RSMAS
  - NOAA/ESRL/PSD (formerly NOAA/ETL)
  - NOAA/OAR Atlantic Oceanographic and Meteorological Laboratory (AOML)
  - NOAA Pacific Marine Environmental Laboratory (PMEL)
- **Synergism**
  - **Low Cost – Low Risk**
  - Engages broader science community on specific problems
  - All parties gain access to all data
  - AEROSE is a key component justifying the PNE cruises

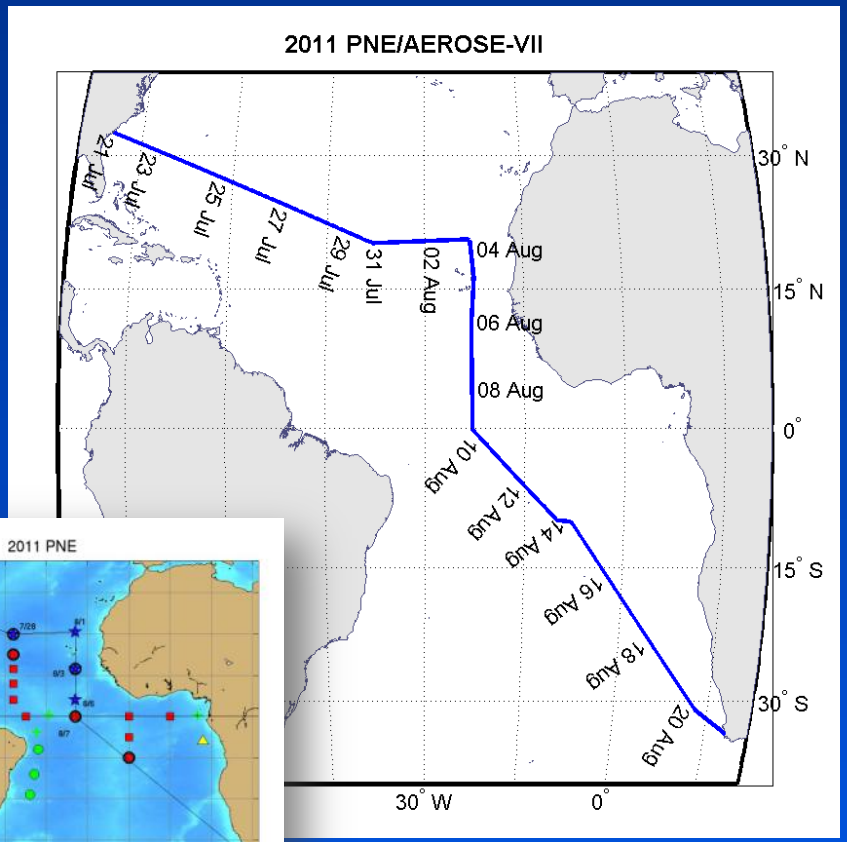
KEY CONTRIBUTORS

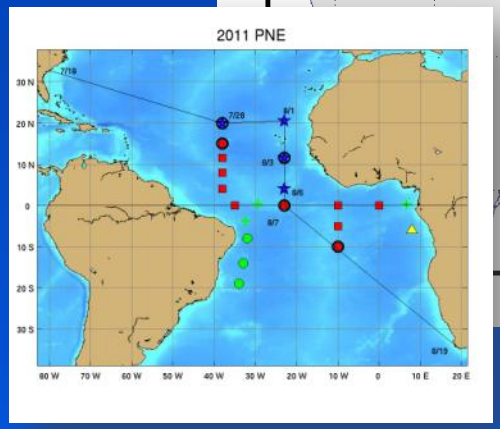
NAME	INSTITUTION	COLLABORATION
N. Nalli, C. Barnet, T. King, H. Xie, T. Reale, E. Maddy, M. Divakarla, G.Guo, A. Gambacorta, W. Wolf, M. Goldberg, et al.	NOAA/NESDIS/STAR	RS92 Rawinsondes; CrIMSS/ GOES-R Proxy Data; EDR Validation; Radiative Transfer; NPROVS
E. Joseph, V. Morris Students M. Oyola, A. Flores, C. Spells, C. Stearns, et al. E. Roper	HU/NCAS Hampton U. Lincoln U.	Aerosol and Chemistry measurements; Radiation Budget; Ozonesondes; Helium
R. Lumpkin C. Schmid	NOAA/AOML	PNE Chief Scientists; TAO Moorings; CTD, XBTs
P. Minnett, M. Szczodrak, M. Izaguirre	UM/RSMAS	M-AER; MW Radiometer; All-sky camera
D. Wolfe	NOAA/OAR/ESRL/PSD	Vaisala Sounding System; Surface Flux Measurements; Vaisala Ceilometer

AEROSE

DATA

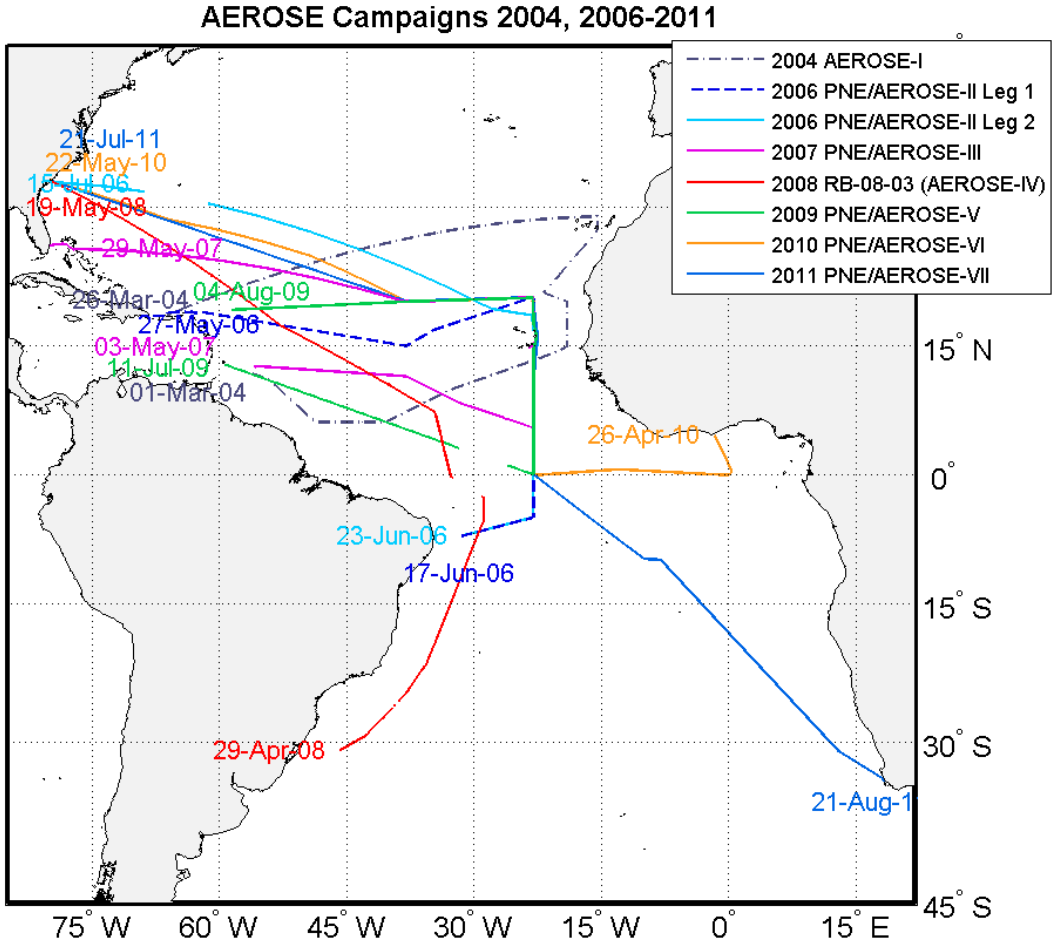
2011 PNE/AEROSE Track





- PNE/AEROSE-VII: Charleston, SC to Cape Town, South Africa
  - Unique interhemispheric transect similar to the **Aerosols99** campaign, but with superior eastern basin sampling
  - Provides a near perfect complement to the **2008 AEROSE-IV** transit, which was over the western basin
  - West-to-east track maximized the probability of encounters with SAL, dust and smoke
- 21 July to 21 August: the climatological peak of dust and smoke outflows

AEROSE Ship Tracks to Date



Correlative Data of Interest

Dedicated RAOBs

- **Vaisala GPS rawinsondes** launched coinciding with AIRS and IASI overpasses
  - Typically 4/day at ~01:30, 09:30, 13:30, 21:30
  - **102 successful 2011 soundings**
  - **680 PTU soundings** to date
  - GPS altitude, $z(t)$, from RS92 sondes
  - 2004, 2008–2011 **not assimilated**, decoupled from land-based RAOB – thus ***truly independent***

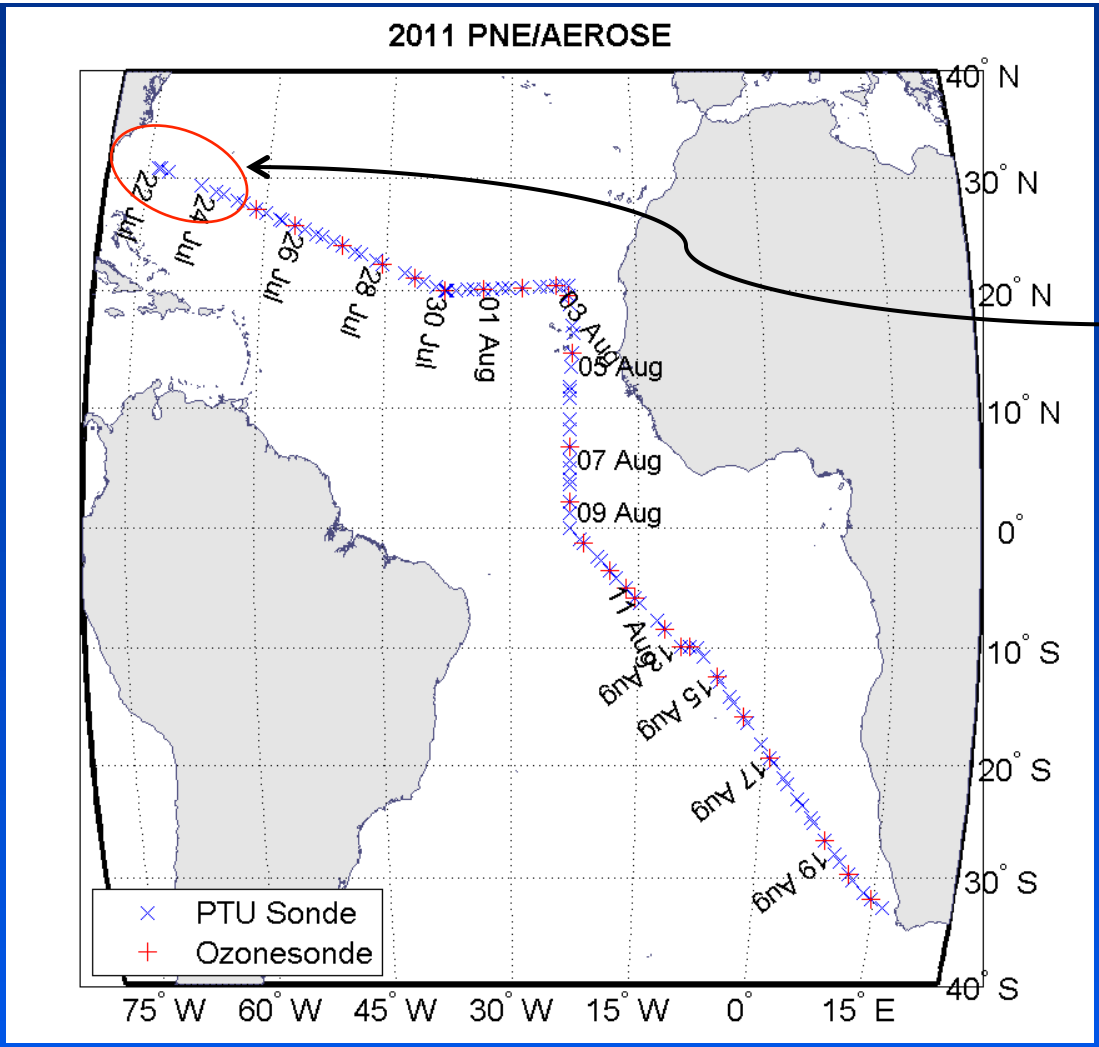
- **Ozonesondes** ~1/day during AIRS/IASI overpasses
  - **24 successful** (full or partial) **2011 soundings**
  - **113 O_3 soundings** to date

M-AERI (*Minnett et al.* 2001)

- **Ship-based FTS** that samples downwelling and upwelling calibrated IR spectra
  - **High accuracy calibration** using 2 NIST-traceable blackbodies (e.g., *Revercomb et al.* 1988)

- **Derived products**
  - **High accuracy skin SST** derived from semi-opaque spectral region (~7.7 μm) (*Smith et al.* 1996), a state parameter *necessary* for forward calculations.
  - Continuous retrievals of lower tropospheric profiles at turbulent time scales
  - Retrieval of spectral surface emissivity (e.g., *Hanafin and Minnett* 2005; *Nalli et al.* 2008b)

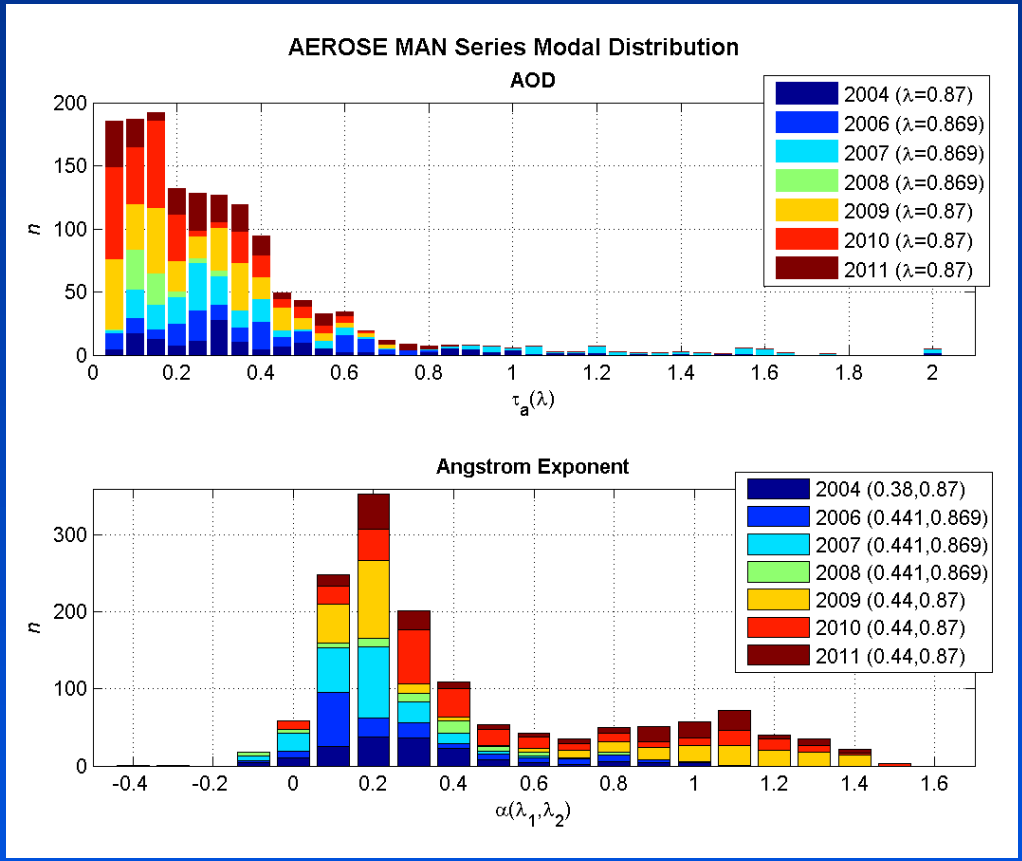
2011 RAOB Launches



Troubleshot problems with sounding system antenna configuration

More Data of Interest

- **Microtops Sunphotometer**
  - Multi-channel aerosol optical depth (AOD)
  - **NASA/GSFC AERONET Maritime Aerosol Network (MAN).** The MAN methodology for Microtops handheld sunphotometers is applied to retrieve a standardized AOD
- Ceilometer (attenuated backscatter for aerosol vertical distribution)
- Broadband pyranometers and pyrgeometers (sfc energy fluxes)
- *In situ* gas & particle measurements
- All-sky camera
- Research-vessel meteorological and oceanographic surface measurements



MAN website: http://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html

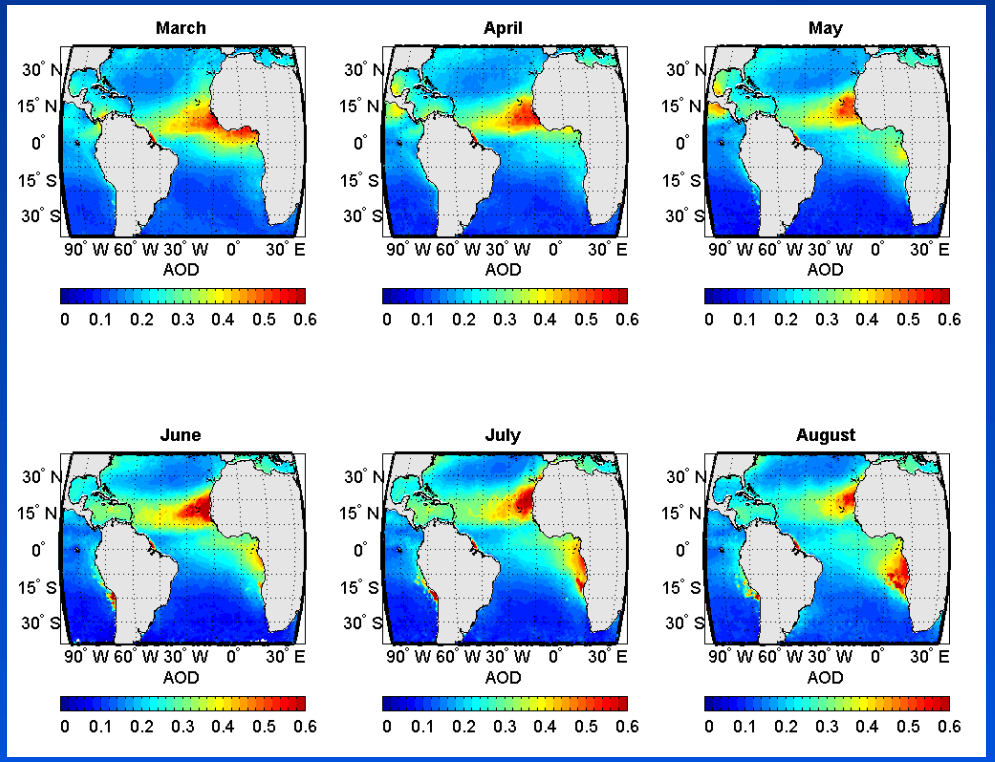
AEROSE

SCIENCE OF INTEREST TO IR SOUNDER MISSIONS…

Dust and Smoke Aerosols

- **~100–400 Tg of mineral dust** are injected into the atmosphere from the Sahara annually (*Prospero et al.* 1981).
  - Peaks during NH summer and springtime
  - Coarse-mode aerosols transported within easterly trade winds well across the Atlantic north of the ITCZ
  - Westward flow accounts for the 30–50% of the dust output
- **Smoke from biomass burning** from sub-Saharan Africa also contribute large quantities of smaller-sized aerosols.
- Significantly impact the meteorology and climate dynamics of the tropical North Atlantic (e.g., **radiation balance, including direct and indirect effects**).
- Due to absorption/scattering, also **impact infrared radiances**, and thus retrievals (e.g., *Nalli and Stowe* 2002; *Weaver et al.* 2003; *Zhang and Zhang* 2008).

AVHRR PATMOS-x AOD Climatology



Saharan Air Layer (SAL) and Tropical Cyclogenesis

- The **Saharan air layer (SAL)** is a dry, warm stable, desert air that advects over Atlantic (*Carlson and Prospero* 1972)
  - Enhanced low level temperature inversion
  - Enhanced vertical wind shear associated with midlevel easterly jet
  - Sometimes contains significant levels of Saharan dust
  - Based upon AEROSE SAL cross-sectional observations (e.g., *Nalli et al.* 2005), **the SAL appears to be a persistent special case of a dry air tongue or dry filament phenomenon as described by *Mapes and Zuidema* (1996)** (*Nalli et al.* 2011)
- SAL conditions hypothetically act to suppress hurricane formation over the Atlantic (e.g., *Dunion and Velden* 2004; *Wong and Dessler* 2005; *Evan et al.* 2006).
- **Satellite sounders** and imagers are tools whereby the SAL can be (and is now being) observed synoptically; this is another reason why **satellite validation in this region is highly desirable**.

Aerosol Impact on the Chemistry of the Tropical Atlantic Atmosphere

- Tropospheric Ozone Dynamics
  - Smoke aerosol precursors from African and South American biomass burning
    - Horizontal advection via easterlies
    - Vertical transport via tropical deep convection
  - Lightening in deep convection – NO_x formation
  - Stratospheric intrusions
- Surface aerosol-gas interactions and transport

AEROSE

ONGOING RESEARCH AND SCIENCE HIGHLIGHTS

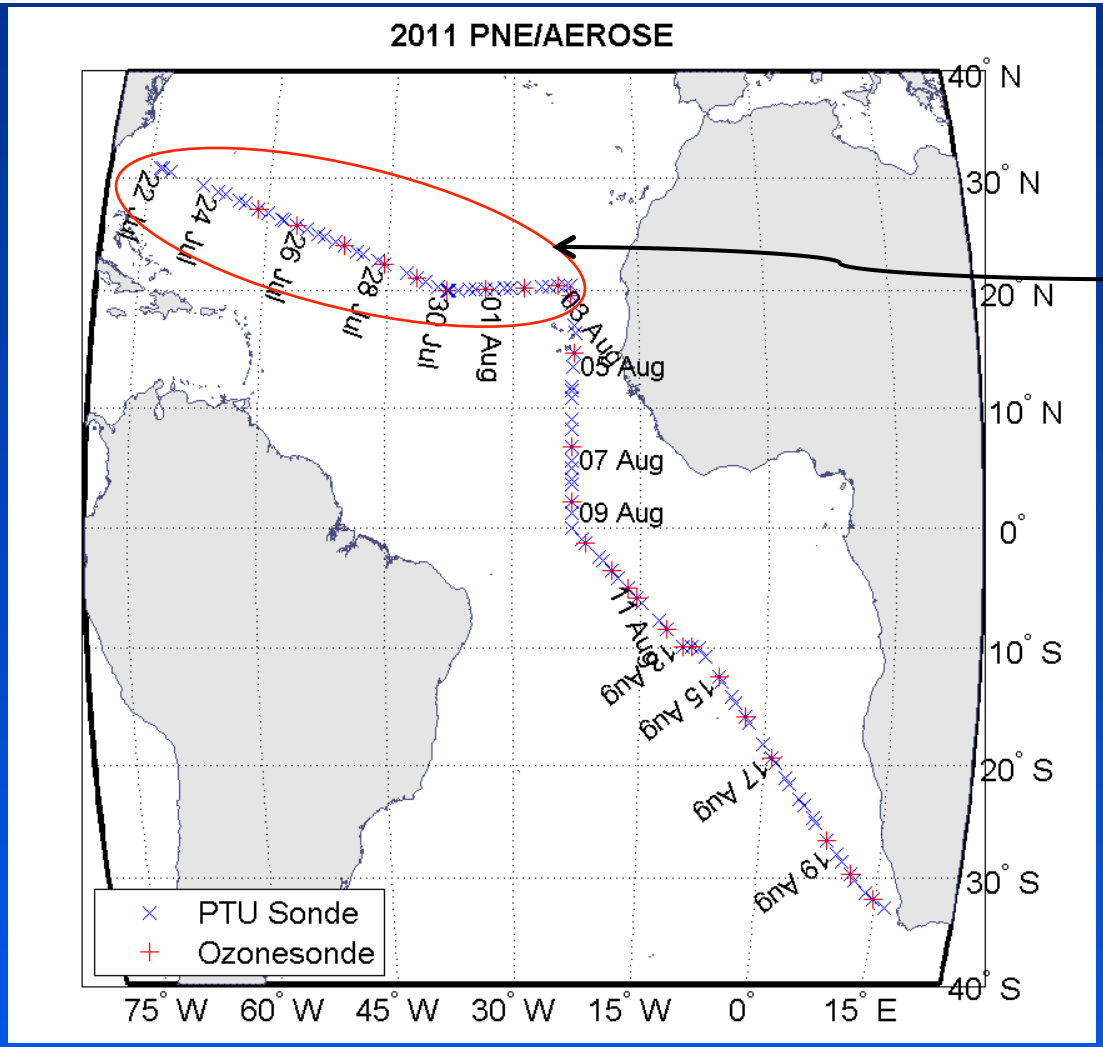
Tuning Validation Methodology: Assessing Impact on Retrieval Products (A. Gambacorta et al.)

- The AEROSE campaign data provides a unique correlative dataset that has advantages for the validation of IASI (and CrIS) tuning, as follows:
  - Dedicated Vaisala RS92 sondes, similar to ARM sites
  - Truly **independent** correlative dataset
    - RAOBs from 2008 – were **not** uploaded into GTS, and thus are **not** assimilated
    - RAOBs located far from any land-based sites; thus, they are *also* independent of land-based RAOBs that *do* end up being assimilated (this *distinguishes* AEROSE from ARM sites)
  - **Location over open ocean** – this is extremely important as it provides far more control over the surface variable (this *also* distinguishes AEROSE from ARM sites)
- Validation of IASI tuning using AEROSE 2008-2011 data is underway (A. Gambacorta et al.). This analysis will serve as a test bed for near future validations of CrIS tuning.

2011 PNE/AEROSE Campaign

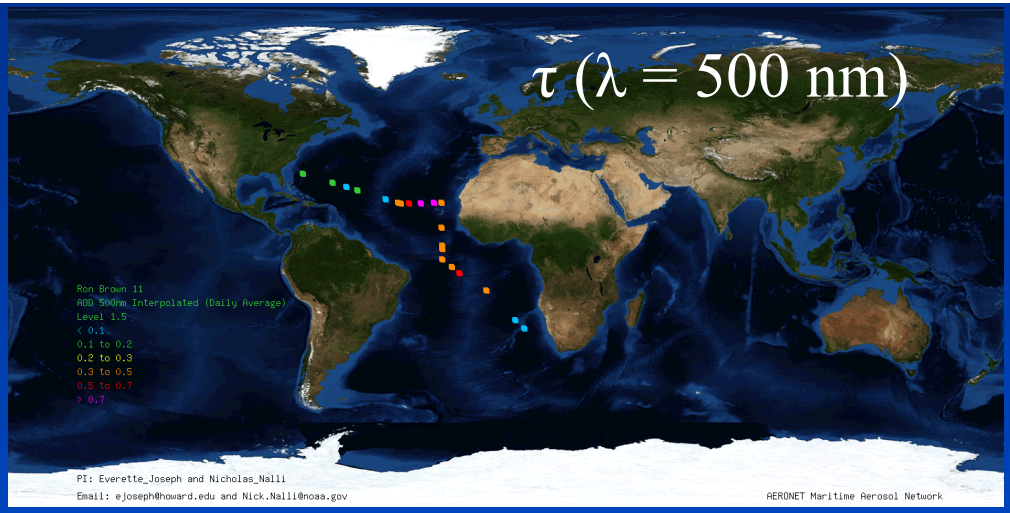
RAOB SOUNDING CROSS-SECTIONS

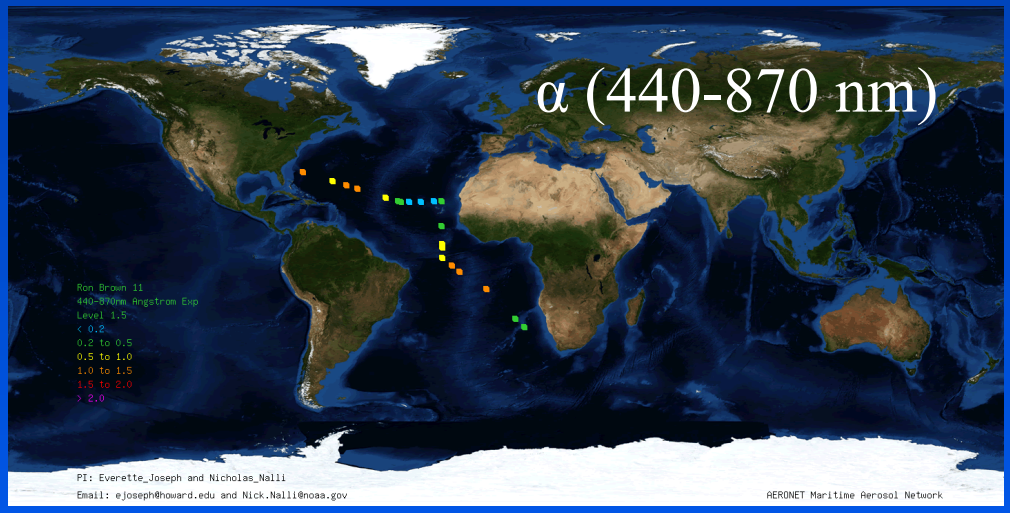
20-32°N WE RAOB Cross-Sections: Tropical North Atlantic



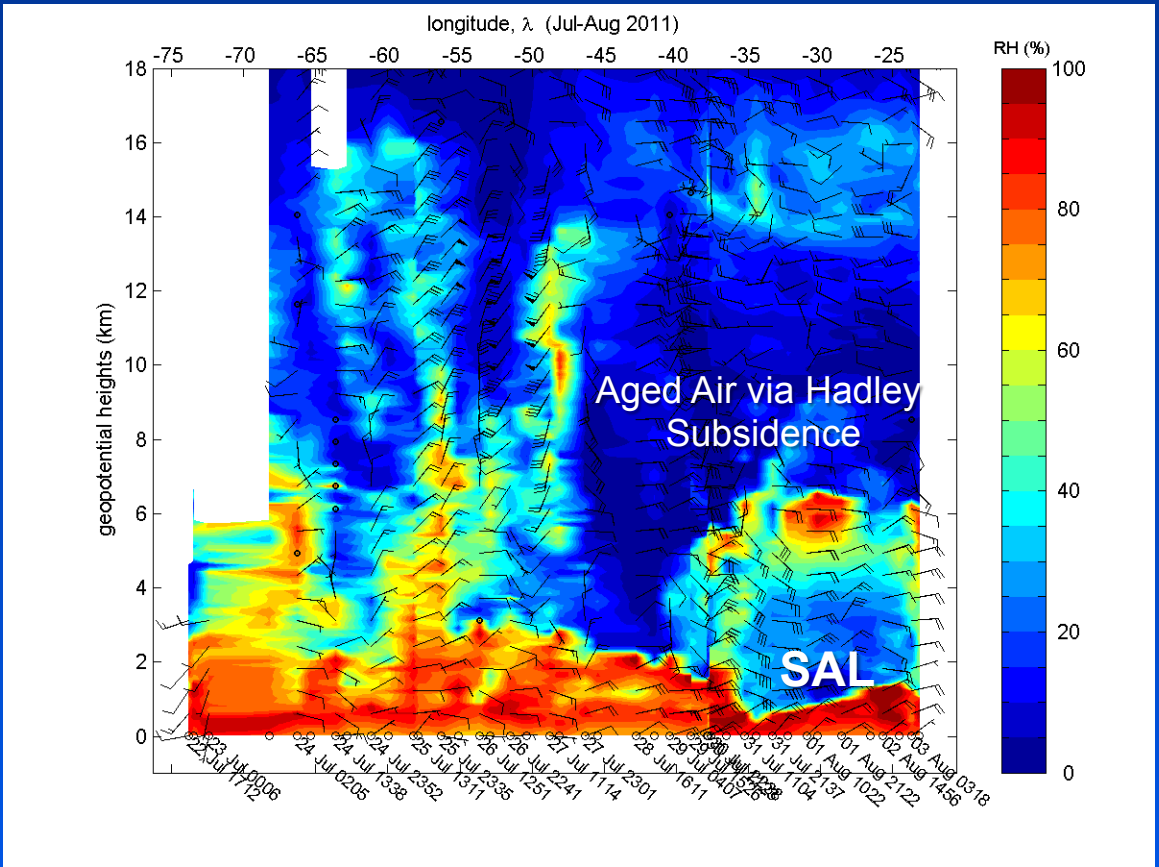
20-32°N W-E Transect

2011 Sunphotometer Observations
(GSFC MAN Methodology, Smirnov et al. 2011)

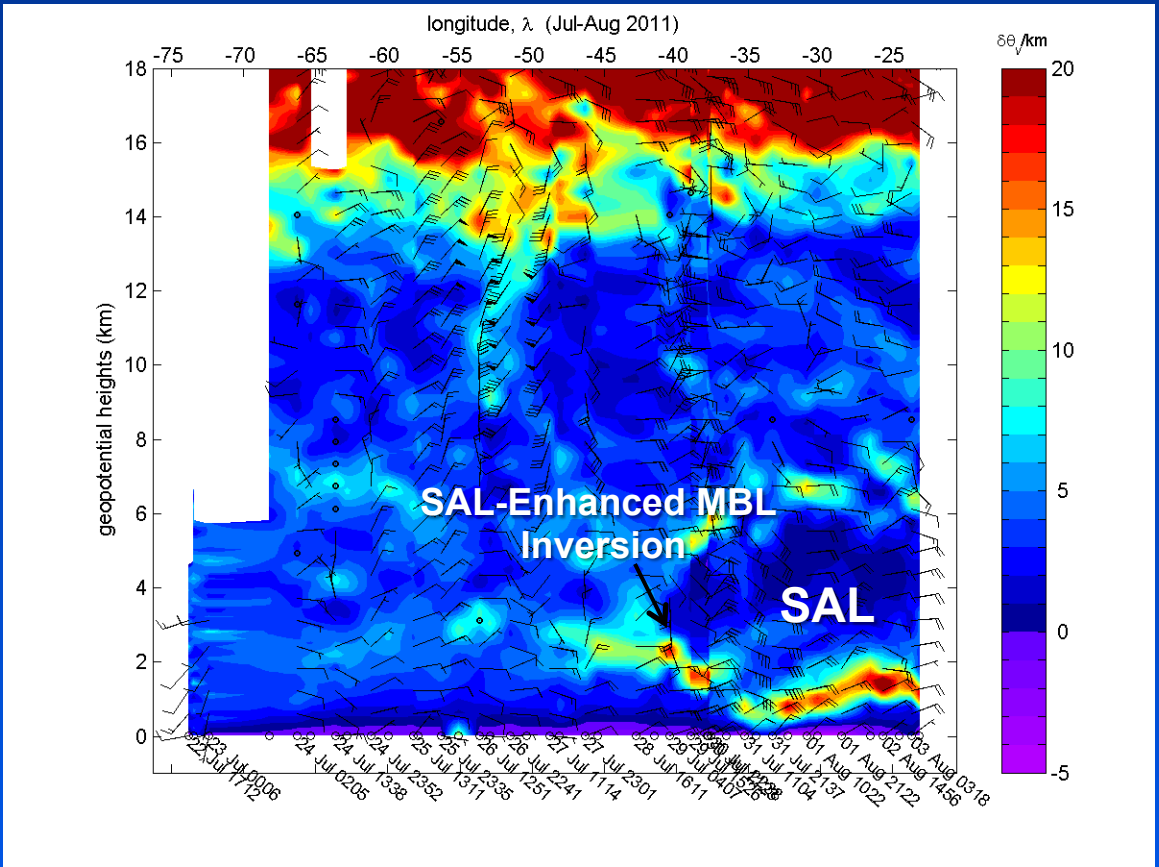




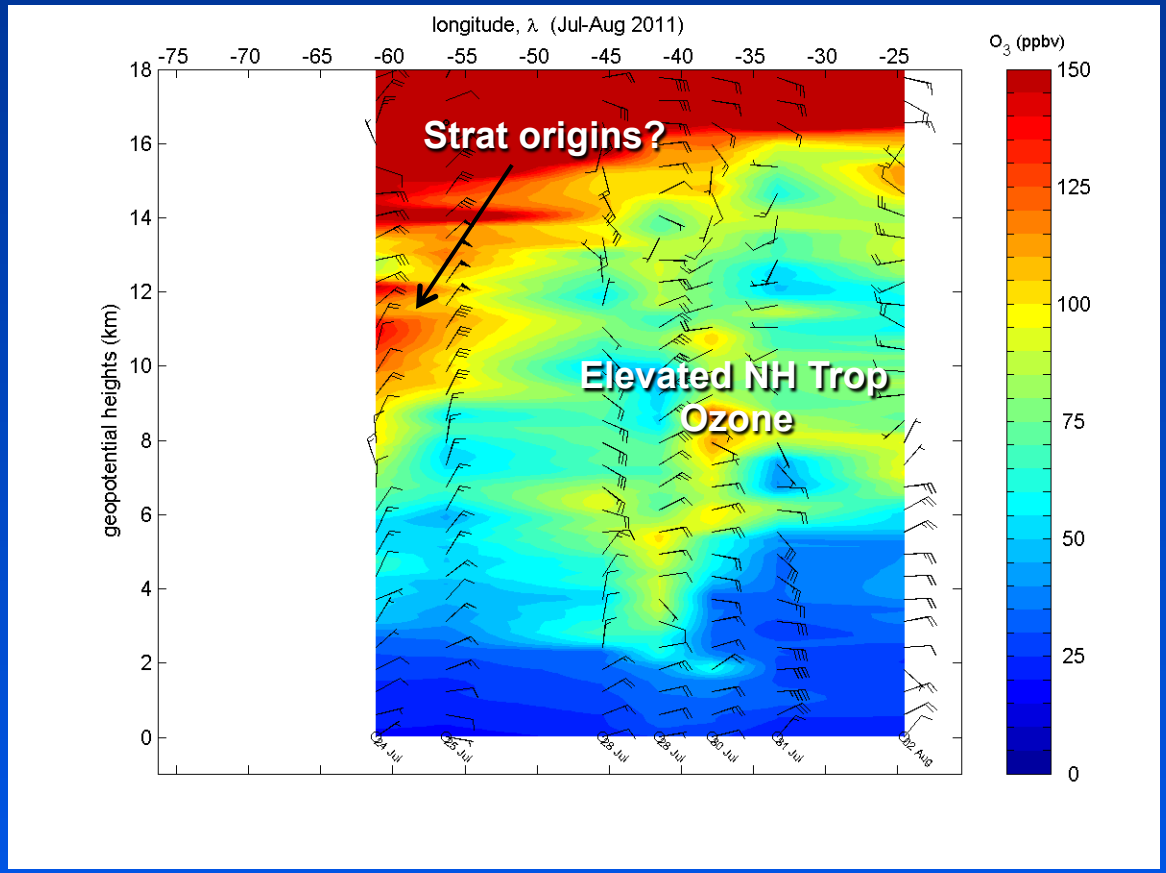
RAOB Tropospheric WE X-Sections 1/3 H_2O (RH)



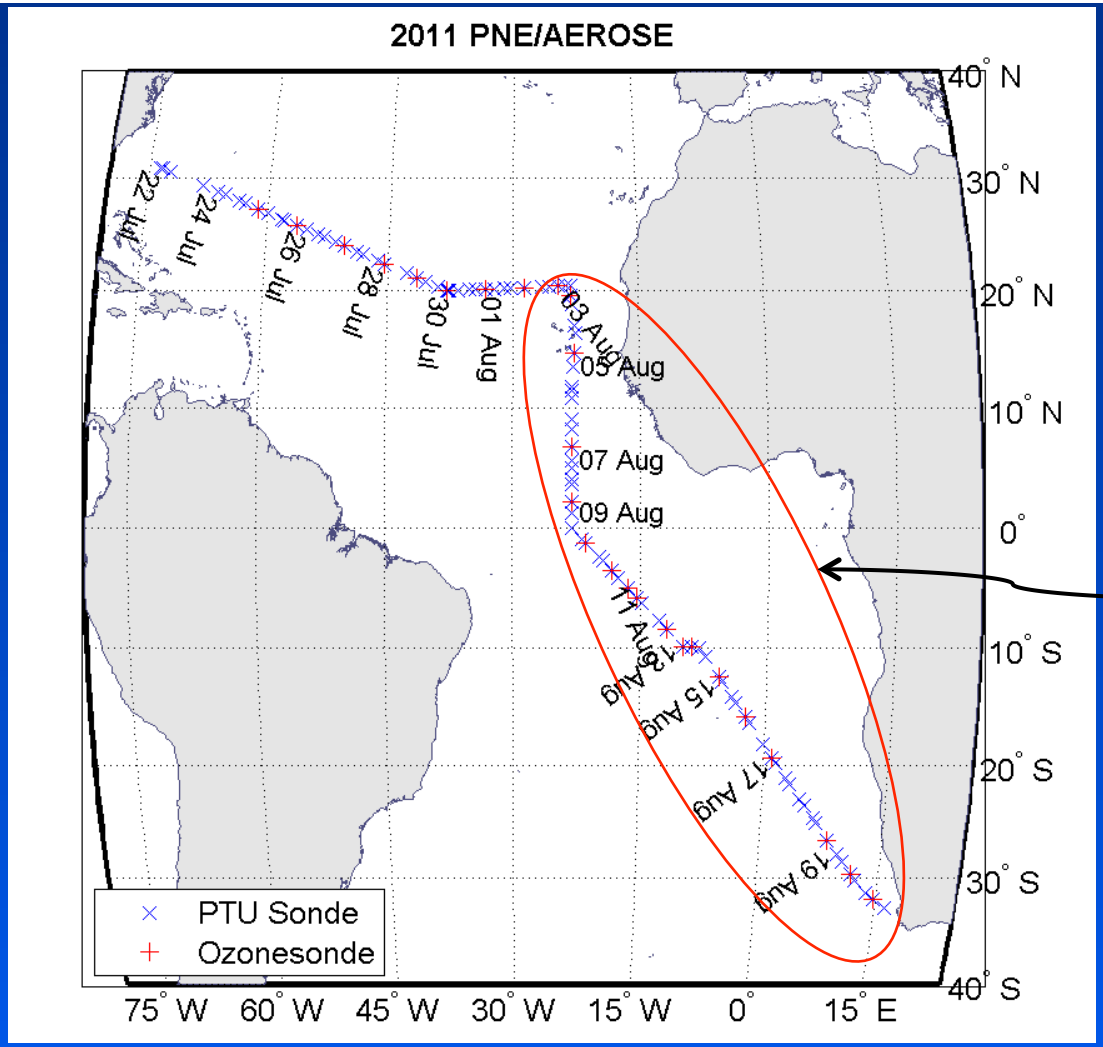
RAOB Tropospheric WE X-Sections 2/3 VPTLR (Static Stability)



RAOB Tropospheric WE X-Sections 3/3
O_3 (ozone mass mixing ratio)

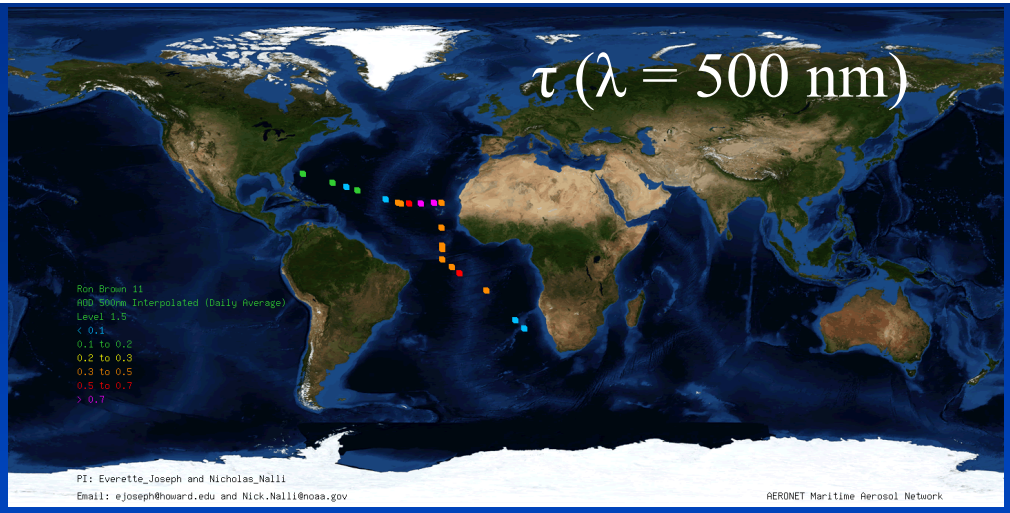


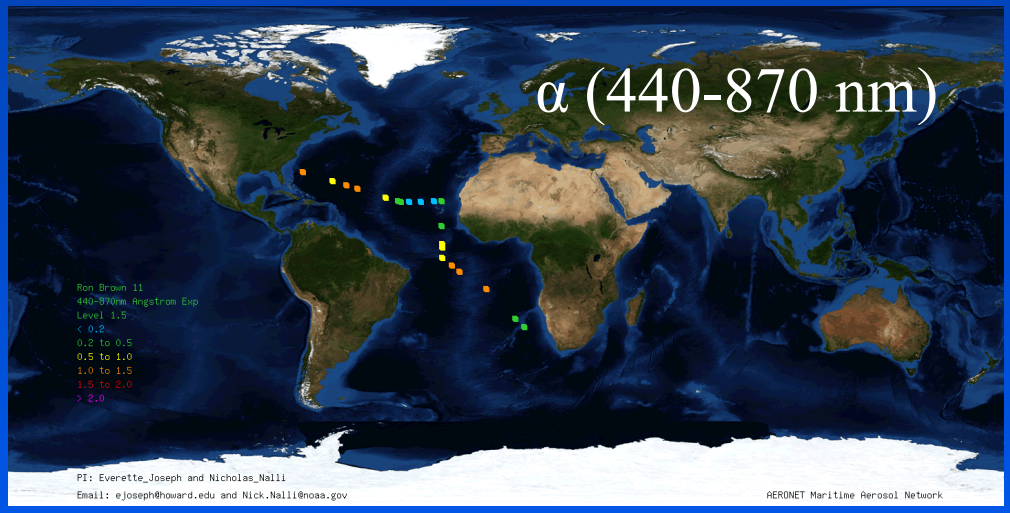
NS RAOB Cross-Sections: Tropical North and South Atlantic



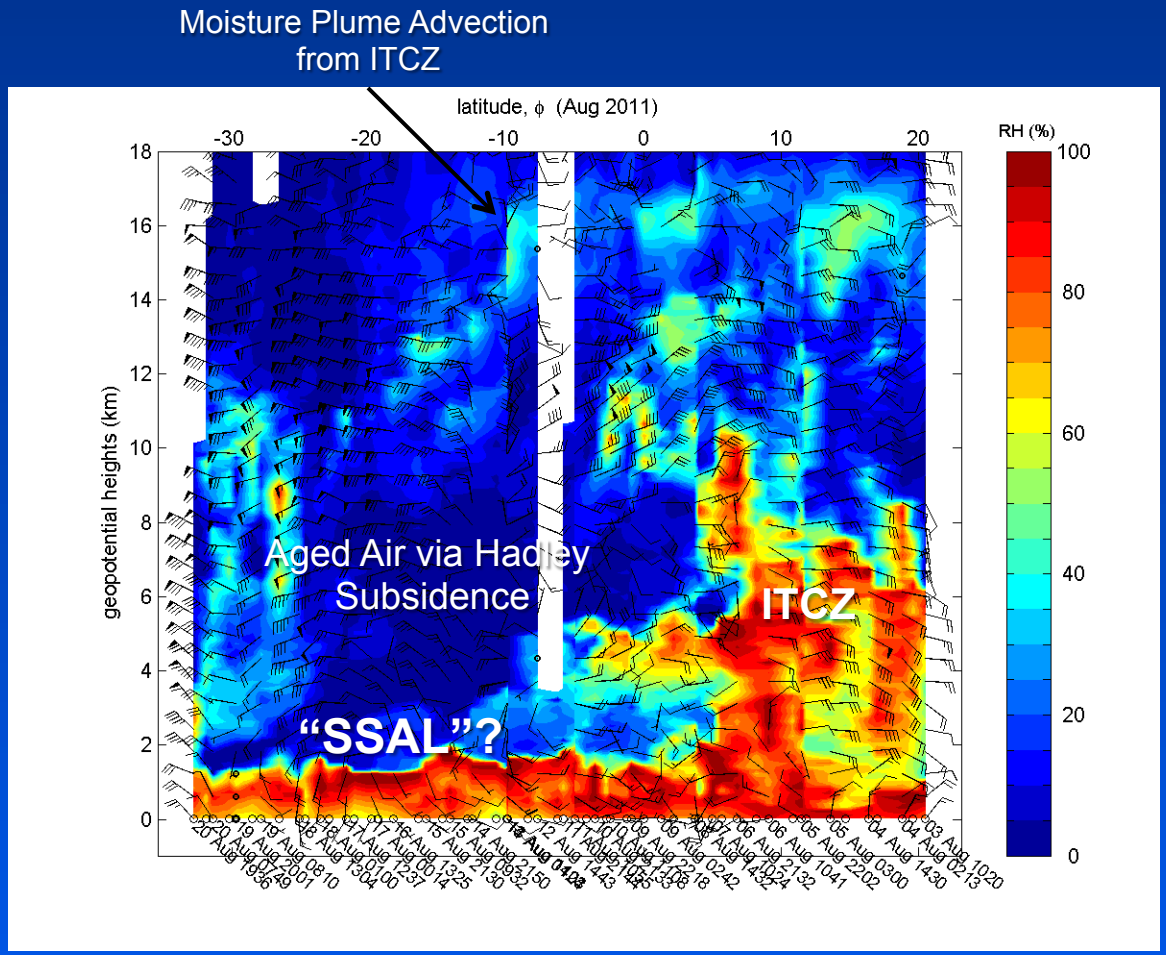
N-S Transect

2011 Sunphotometer Observations
(GSFC MAN Methodology, Smirnov et al. 2011)

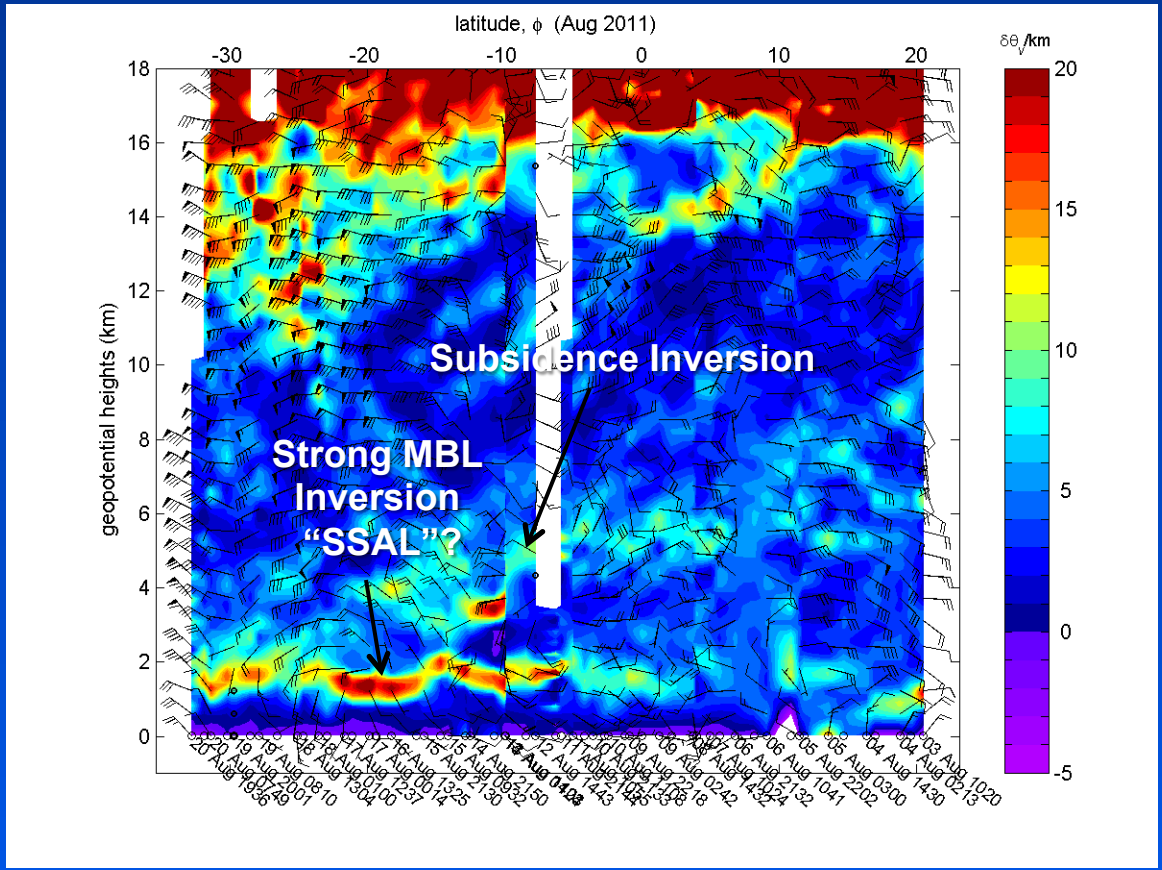




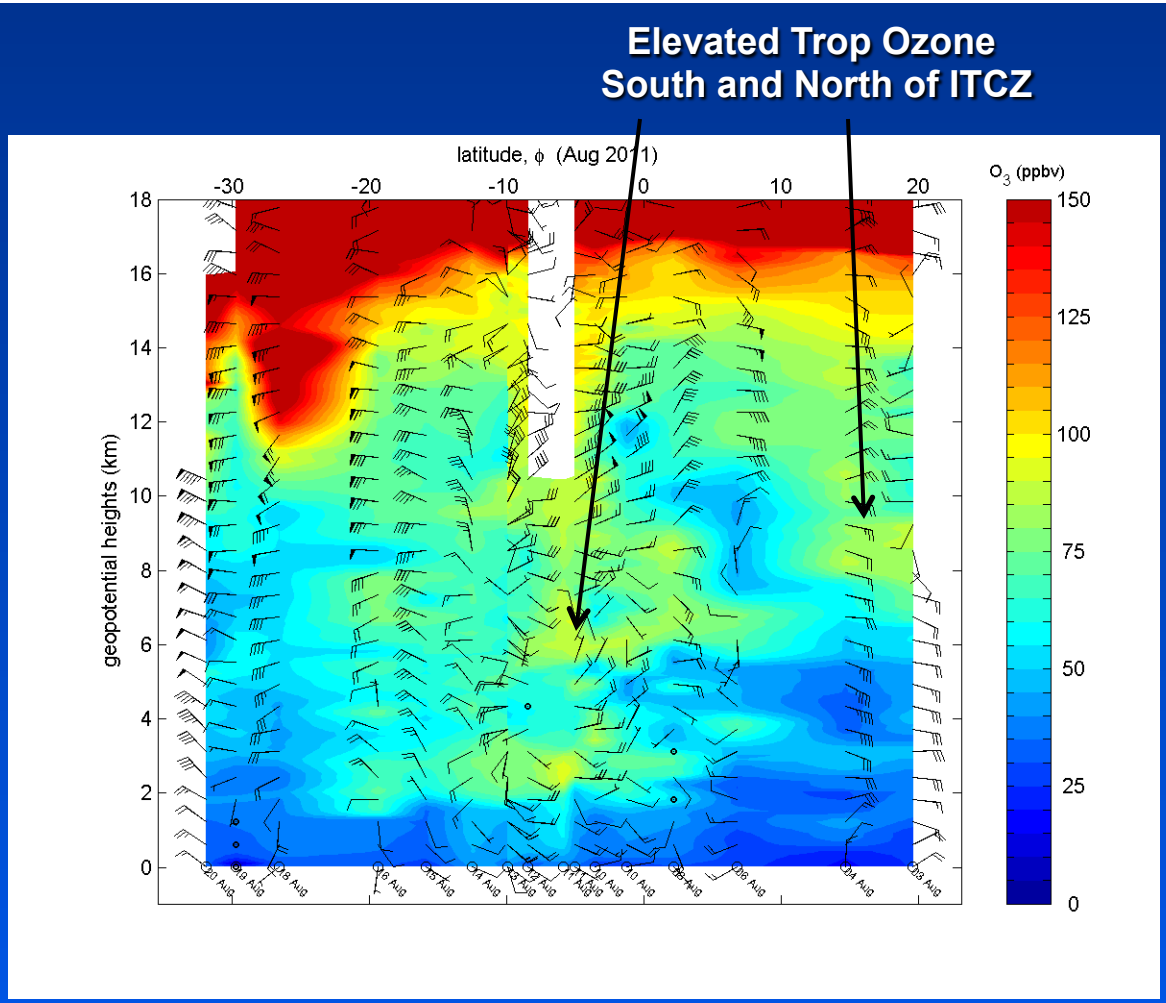
RAOB Tropospheric NS X-Sections 1/3 H_2O (RH)



RAOB Tropospheric NS X-Sections 2/3 VPTLR (Static Stability)



RAOB Tropospheric NS X-Sections 3/3
O_3 (ozone mass mixing ratio)

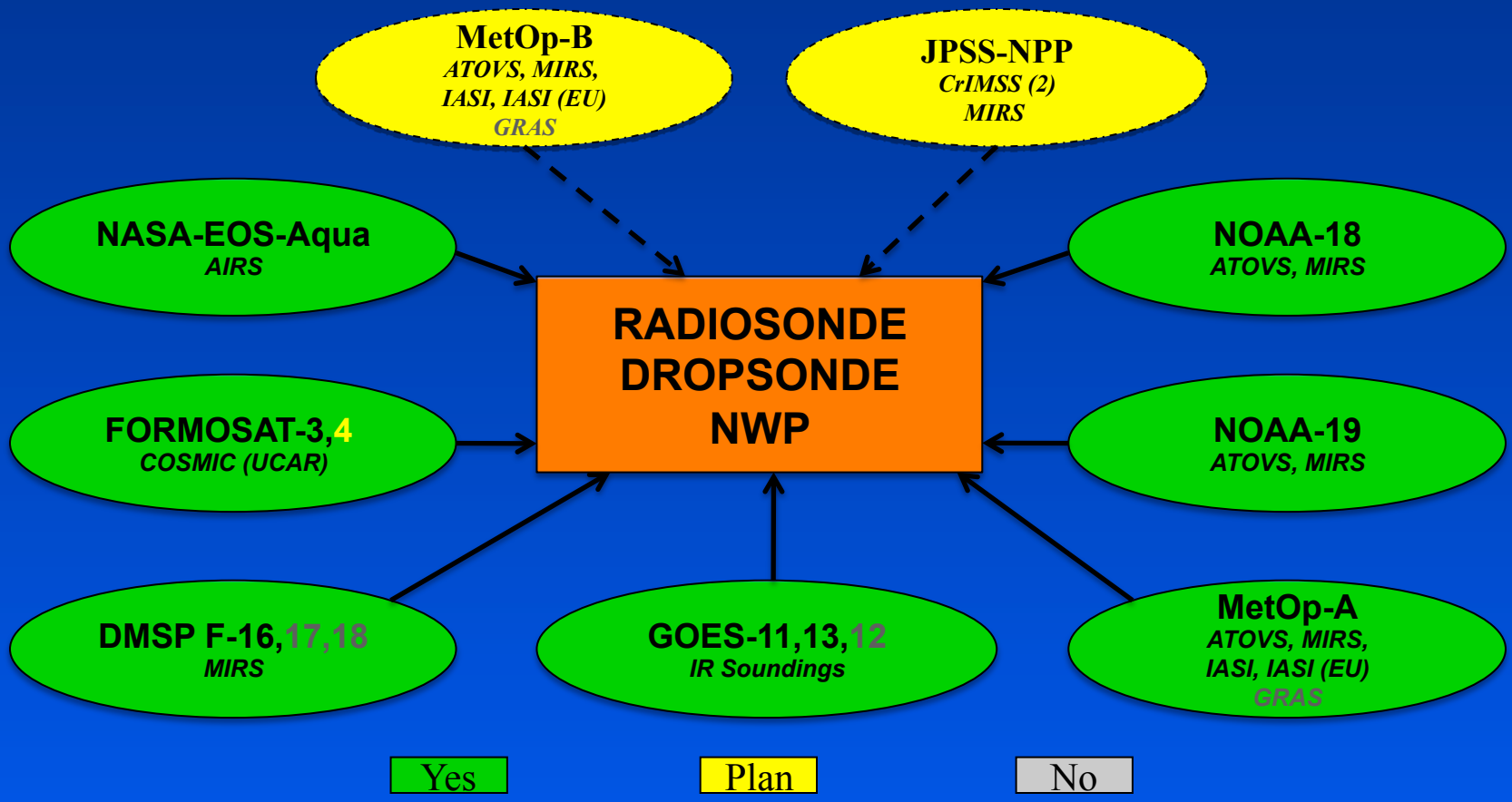


NOAA Products Validation System (NPROVS) (Reale et al.)

Tony Reale (NOAA/STAR/OPDB)

Bomin Sun, Frank Tilley and Michael Pettey (IMSG)

NPROVS Schematic
(Reale et al.)

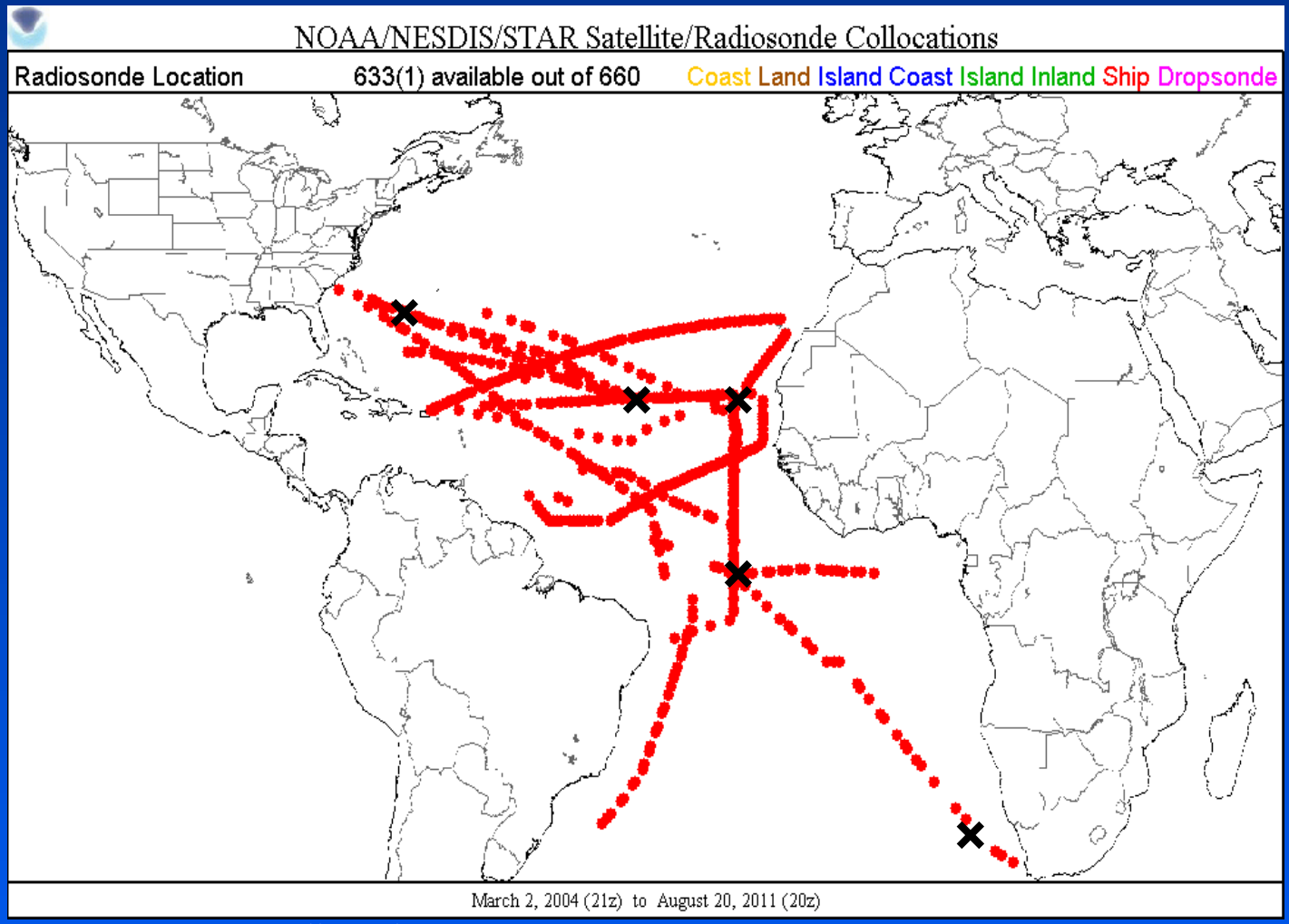


NPROVS and Special Field Campaigns
(Reale et al.)

- ConcordIASI Antarctic Dropsonde Experiment (Sep-Dec 2011)
- GCOS Reference Upper Air Network (GRUAN)
  - routine NPP EDR validation
- **NOAA AEROSE (2004, 2006–2011, …?)**

NPROVS: *All* AEROSE (2004, 2006-11) RAOBs collocated with IASI and AIRS (Reale et al.)

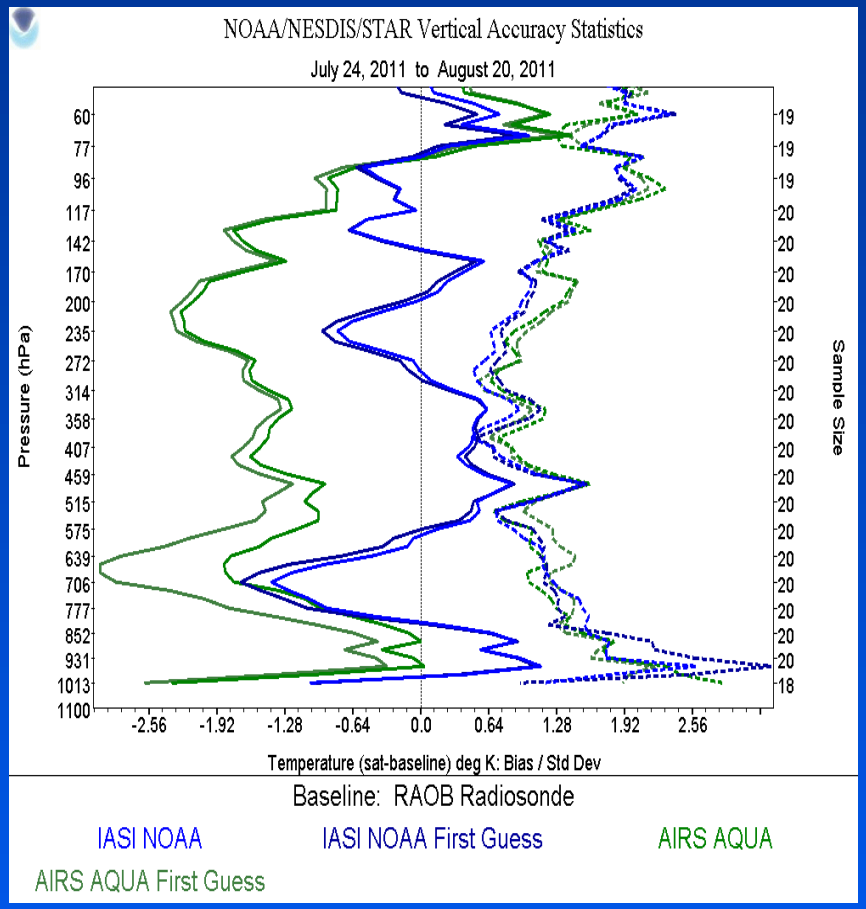
x = 2011



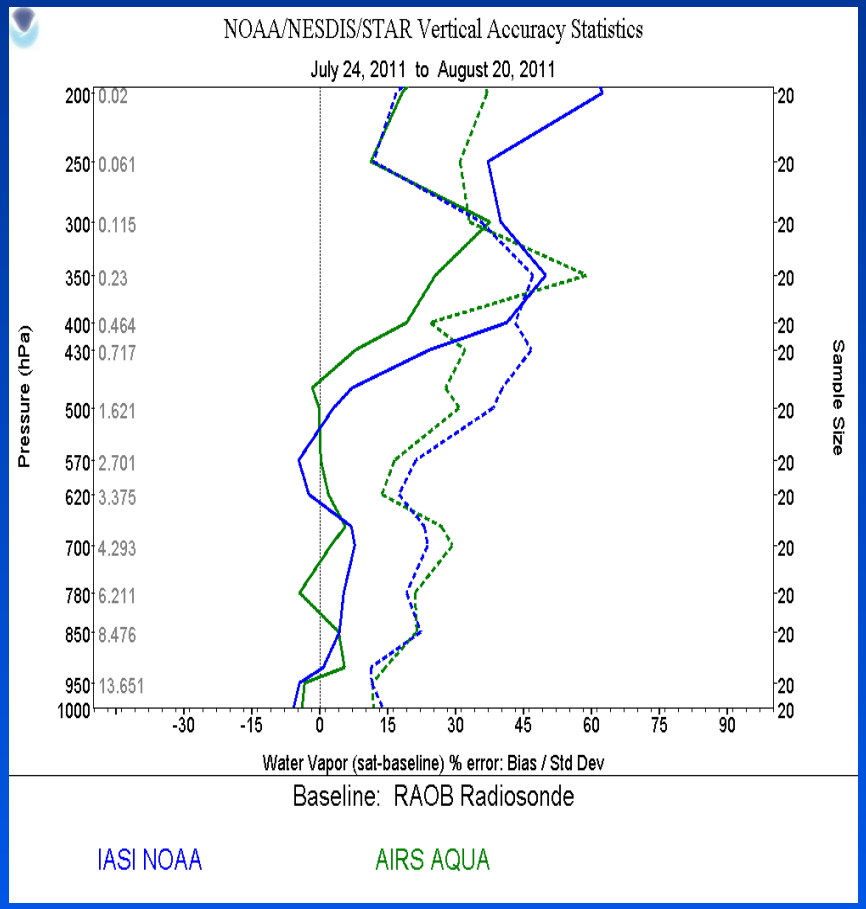
Sat-minus-Sonde mean and SD differences (Levels)

20 collocations containing AIRS v5 and NOAA IASI which passed QC (Reale et al.)

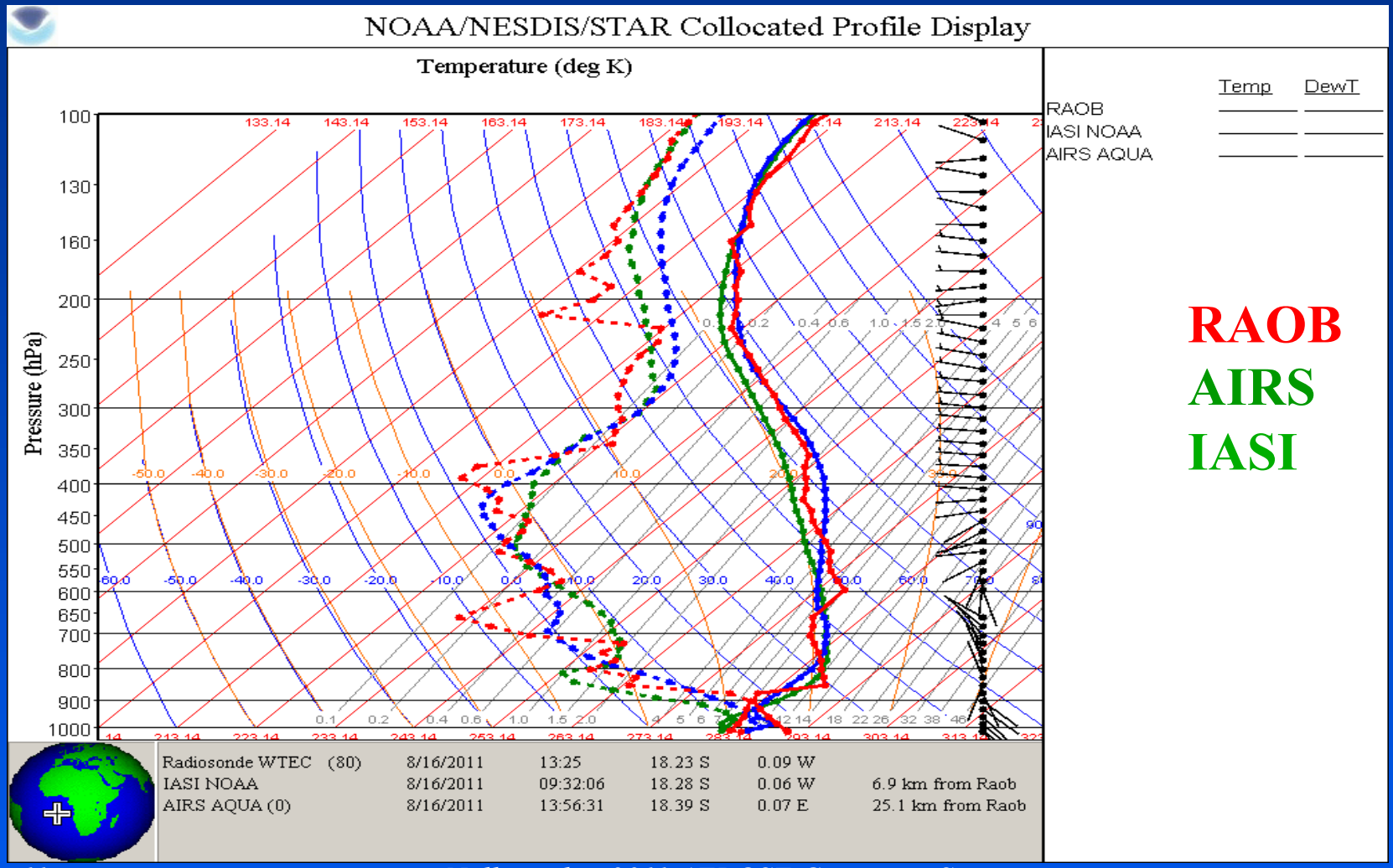
Temperature



Water Vapor



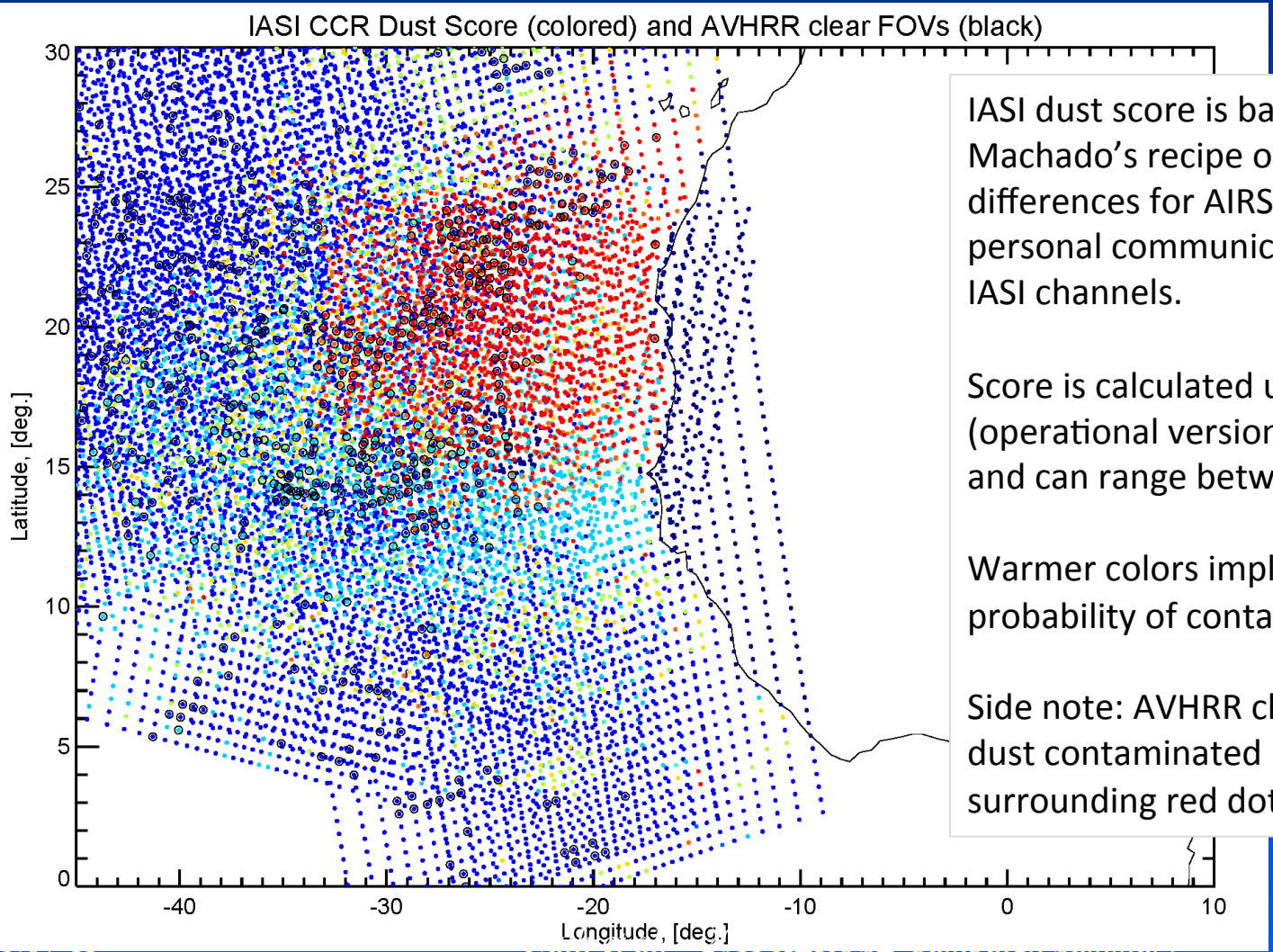
NPROVS AEROSE 2011 Sounding Matchup in vicinity of Biomass Burning Smoke Plume
(Reale et al.)



Impact of Dust on IASI Retrievals

(E. Maddy et al.)

IASI CCR dust scores 07/23/2011-08/01/2011



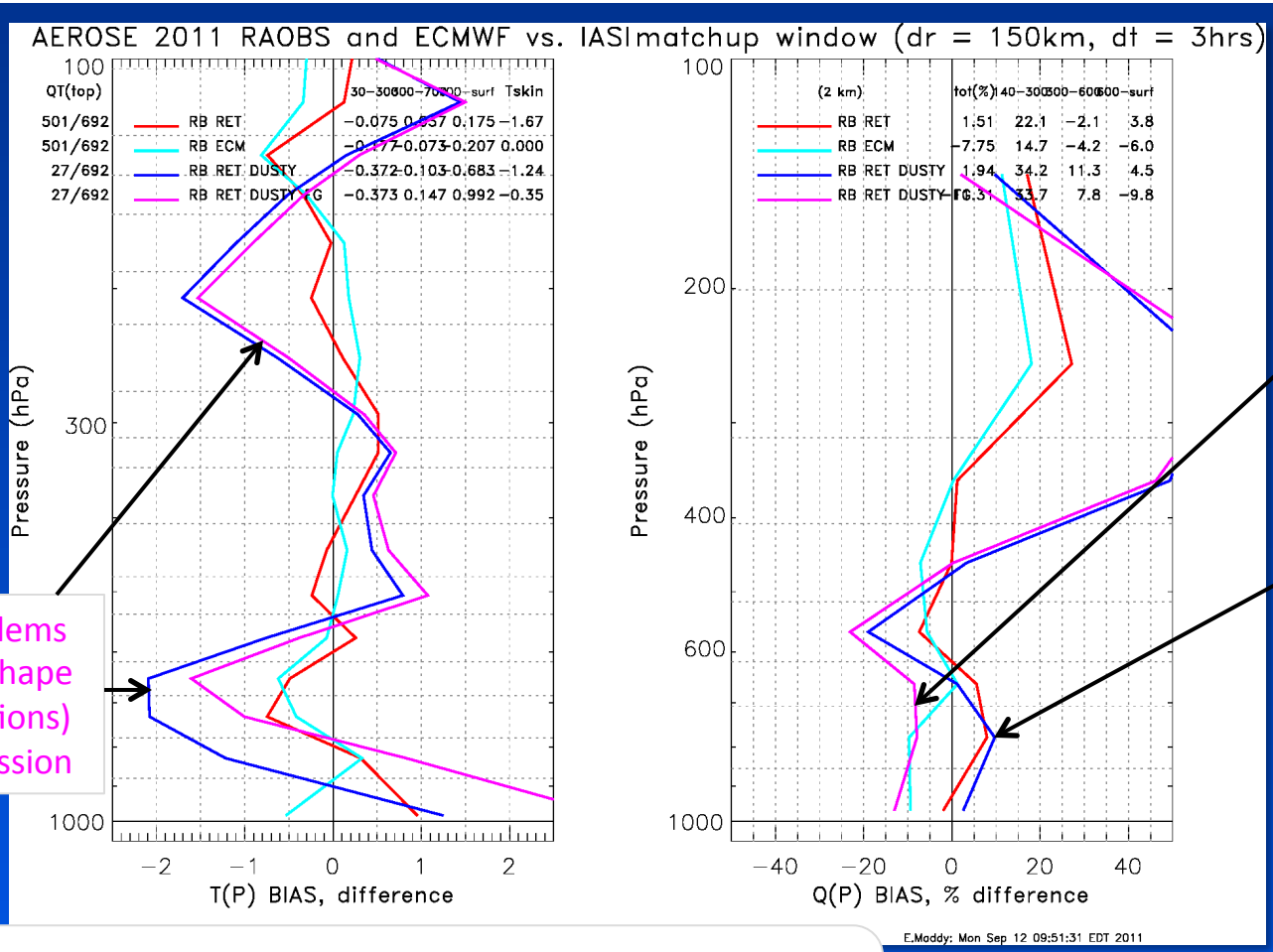
IASI dust score is based on S. DeSouza-Machado's recipe of channel differences for AIRS (GSFC, JPL, UMBC, personal communication) for similar IASI channels.

Score is calculated using IASI CCRs (operational version + new regressions) and can range between 0 and 511.

Warmer colors implies higher probability of contamination

Side note: AVHRR clear scenes can be dust contaminated (see black circles surrounding red dots).

Impact of Dust/SAL on IASI Retrievals
(E. Maddy et al.)



Some problems inherited (shape and oscillations) from regression

Regression has dry bias in lower troposphere

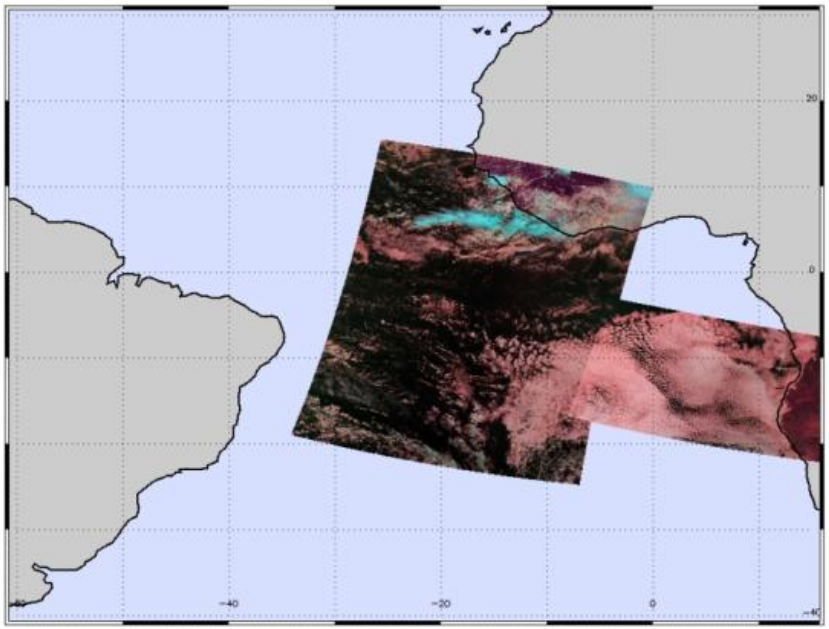
Cold RET T(p) bias translates into the RET adding more H2O(p) to compensate?

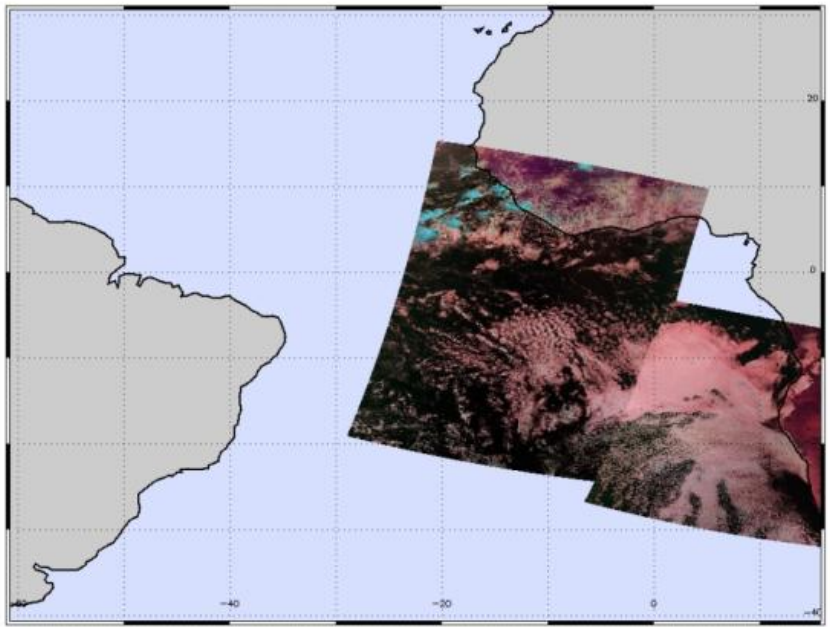
M. Divakarla to show CrIMSS EDR results based upon proxy data…

RB RET = RAOB − RETRIEVAL
RB ECM = RAOB − ECMWF
RB RET DUSTY = RAOB − RETRIEVAL cases with CCR dust score > 300
RB ECM DUSTY FG = RAOB − REGRESSION cases with CCR dust score > 300

Regional Impact of Smoke as CCN?

13 August 2011 **14 August 2011**





MetOp AVHRR for AEROSE matchup granules

Final Remarks

- The **NOAA PNE/AEROSE** intensive campaigns continue to compile a multiyear set of ship-based, marine *in situ* **cross-sectional correlative measurements** (IASI, AIRS and SEVIRI matchups) over the tropical Atlantic Ocean.
- The AEROSE domain spans a **region of marine meteorological interest** for sounder missions.
- **2011 AEROSE highlights** include
  - Unique interhemispheric transit similar to Aerosols99 cruise, revealing interesting and important meteorological phenomena, including dry, stable low-level layer, and enhanced trop ozone, south of ITCZ, and possibly large scale cloud-seeding via biomass burning smoke
  - AEROSE soundings ingested into NPROVS for cal/val (T. Reale et al.)
  - Preliminary **IASI L2 analyses show adverse impact of dust on NOAA IASI retrievals** (E. Maddy et al.); M. Divakarla to show results based on CrIMSS proxy data
- The next PNE/AEROSE campaign is tentatively scheduled for September 2012 – hurricane season!

Acknowledgements

- The Howard University **NOAA Center for Atmospheric Sciences (NCAS)**, supported by
  - The **NOAA Minority Serving Institutions Educational Partnership Program**
  - National Science Foundation Career Grant (ATM-9703167)
  - NASA Grant (NG-1224)
- The **Joint Polar Sounding System** (formerly Integrated Program Office)
- The **NOAA GOES-R Algorithm Working Group** (W. W. Wolf) Proxy Data and Soundings Application Teams
- The NOAA **PIRATA Northeast Extension (PNE)** Project
- **M. D. Goldberg,** P. Clemente-Colón (NOAA/NESDIS/STAR)
- **T. Pagano**, E. Fetzer (JPL), and **the NASA Sounder Science Team**
- **M. Szczodrak**, M. Izaguirre (UM/RSMAS); W. Feltz, R. Knuteson (UW); E. Roper (Lincoln Univ.)
- M. Oyola, C. Spells, J. Perry, A. Flores, C. Stearns, and many other students…
- The **officers and crew of the *Ronald H. Brown*** for their professional support and contributions.